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Physical characteristics, antioxidant activity and microbial quality of tomato powder

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Abstract
Tomato powder was prepared using three different temperatures i.e. 50, 60 & 70 °C at 53% Rh for 18, 12 and 10 h, respectively. Physical characteristics, antioxidant activity and microbial load were determined using standard methods. Tomato powder prepared at 50 °C and 60 °C were good in color while powder prepared at 70 °C showed significant darkening. Water absorption capacity was found highest for powder prepared at 60 °C. The DPPH free radical scavenging activities of various types of tomato powders were found between 45.41 to 58.00 per cent. The highest Antioxidant activity was found in tomato powder prepared at 50 °C and lowest in prepared at 70 °C. The total plate count (TPC) of tomato powder prepared at 50 °C and 60 °C were approximately similar i.e. 36 x 10^4 cfu/g and 35 x 10^4cfu/g, while found lowest i.e. 14 x 10^4 cfu/g for powder prepared at 70 °C. The overall concentration of Total viable counts were found lower in all types of tomato powder when compared to PHLS (Public Health Leadership Society) standards which showed good microbiological quality of prepared tomato powders using experimental processing conditions. Tomato powder prepared at 60 °C for 12 h at 53% Rh is was found optimum keeping in view all the parameters.

Keywords: antioxidant activity, DPPH, physical characteristics, public health leadership society, total viable count

Introduction

Tomatoes are important vegetable crop grown worldwide and possess number of health benefits owing to the presence of vitamins, minerals, flavonoids and carotenoids which are potent antioxidants and have protective effect against various degenerative diseases (Sesso *et al.*, 2004; Willcox *et al.*, 2003; Leonardi *et al.*, 2000) [26, 14]. Although, it is an integral part of many cuisines and nutritionally rich, the limiting shelf life decreases the potential utilization of this important vegetable crop. Moreover, current hurried and hectic lifestyle resulted in increasing growth and popularity of convenient food industry in many Asian countries hence, further stimulated the increasing demand for high-quality dehydrated vegetables and fruits. Dehydrated fruit and vegetable powders obtained by drying are an ideal addition to soups, sauces, marinades, extruded cereal products, fruit purees, fillings, baby foods and also of anti-aging preparations (Francis and Phelps, 2003; Potter *et al.*, 2013) [8, 20]. The market for dehydrated fruits and vegetables in the Japan alone is of US$ 7.6 billion and in China, Europe and USA is US$ 800, 260 and 125 million, respectively. This trend is expected to continue and even accelerate over the next decade in all emerging economies of the world (Liu, 2003; Japan Statistics Bureau, 2000; FAS Online, 2002).Therefore, the present study was undertaken to determine physical characteristics, antioxidant potential and microbial safety of tomato powder manufactured for various kind of applications.

AA- Antioxidant activity
CFU- Colony forming units
TPC- Total Plate Count
PHLS- Public Health Leadership Society

Materials and methods

Sample collection and preparation

Fresh tomatoes (*Lycopersicon esculentum)* of var. 'Himsona' [Syngenta AG] of 4-5 cm. in length were selected for study. The process for the production of tomato powder was standardized using three different temperatures i.e. 50, 60 & 70 °C at 53% Rh for 18, 12 and 10 h respectively, in industrial type tray dryer. The process flow chart for the production of tomato powder has been described in Fig.1. Prepared tomato powder was filled in sealed aluminum foil sachets (pack size 100g) and then packaged in the high-density polythene bags (thickness 80µ) by double sealing and stored at -18 °C in deep freezer.

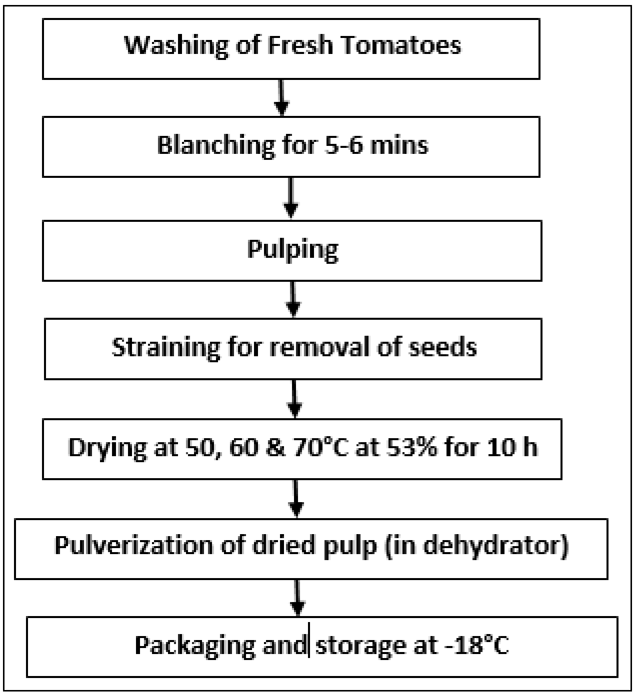

Fig 1: Process flow chart for the production of tomato powder

Physical characteristics analysis
All the three variations of tomato powder were analyzed for their physical characteristics i.e. color, water absorption capacity and particle size distribution to select the best drying temperature. Color of tomato powder was evaluated by Munsell Color Chart (Munsell Colour Company, Inc., Baltimore, Maryland, 1954) [18] The values were expressed in terms of hue, value and chroma. The particle Size index of the tomato powder was determined according to the method of Bedolla and Rooney, (1984) [3] by sieving 100 g flour on a series of no. 36 (400 µm), 60 (250µm), 85 (180µm) and 100 (150µm) mesh standard sieves shaken for 15 minutes in a Ro–tap type sieve shaker. Water absorption capacity of tomato powder was estimated by the method of Smith and Circle (1972).

Measurement of antioxidant activity
The antioxidant activity of tomato powder was estimated by the method of Zhang and Hamauzu, (2004) [27] with some modifications. 10 g of tomato powder was homogenized with 15 ml of 80% methanol. The homogenate was filtered through four layers of cheesecloth and the residue was treated added with 15 ml of 80% methanol for two successive extractions. The filtrates were combined and centrifuged at 4000 rpm for 10 minutes. The supernatant of methanol extract was collected and diluted to various concentrations (1%, 2.5%, 5%, 7.5 and 10%) for measurement of total antioxidant activity 5% solution was found appropriate. Antioxidant activity was determined by using 1, 1- diphenyl -2- picryl-hydrazyl (DPPH) purchased from Sigma-Aldrich (India). All the reagents were of analytical grade. Solution of DPPH 0.1 mM in methanol was prepared and 4 ml of this solution was treated with 0.2 ml of diluted extract. A control was treated with 0.2 ml of distilled water instead of the extract. The mixture was left to stand for 60 minute before the decrease in absorbance. Absorbance at 517nm was measured by UV-vis spectrophotometer (MultiSpec-1501, Shimadzu, Japan). Antioxidant activity was expressed as the percentage of DPPH radical decrease using the equation.

$$AA (\%) = [(A_{sample} – A_{sample\ blank})/A_{control}] \times 100$$

$A_{control}$ is the absorbance of the control (DPPH solution without the sample). A_{sample} is the absorbance of the sample (DPPH solution with the sample). $A_{sample\ blank}$ is the absorbance of the sample solution without DPPH.

Microbial load determination
The total plate count (TPC) and yeast and mould count was estimated in the sample of tomato powder prepared at 50, 60 and 70 °C.

Total plate count (TPC) of tomato powder and developed products
Total bacterial count of samples were determined using standard plate count (SPC) technique as given in compendium of methods for microbiological examination of foods (APHA, 1984**).** This technique gives total number of viable cells of bacteria present in the sample, therefore, also called as Total viable cell count (TVC) technique or serial dilution technique.

Sterilization of glass wares
All glassware used in microbiological work was of Borosil make. Prior to start of experiment glassware were sterilized in the hot air oven at 180˚C for 2 h **(**Busta *et al.*, 1976**).**

Preparation of peptone water
For the analysis, peptone water was used for preparing dilutions. Peptone water was prepared by dissolving 0.1 g of peptone and 0.5 g of NaCl in 100 ml distilled water (pH 7.2). After preparing solution, it was sterilized by autoclaving at 121 °C (15 lbs pressure) for 15 minutes and then cooled to 45 ˚C before use.

Preparation of sample dilutions
10 g of sample was blended with sterilized 0.1 per cent peptone water and volume was made up to 100 ml with the same solution. This constituted first dilution (1:10). The suspension was then shaken thoroughly by hand shaking for 2 minutes and subsequent dilutions were made using sterilized 0.1 per cent peptone water. 1 ml of this suspension was aseptically transferred to 9.0 ml of sterilized peptone water tube, thus making 10^{-2} dilution (1:100). In the same fashion, dilutions of 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} were prepared. Plate count agar was used to determine the total viable counts in all the samples. Appropriate dilutions of the sample (1ml) were transferred aseptically to sterile petri plates in duplicate and mixed well with 10-15 ml of pre sterilized plate count agar at 45ºC. After solidification plates were incubated at 37 ºC for 24-48 h in bacteriological incubator. Colonies were counted using colony counter. The dilution plates showing the number of colonies in the statistical range of 30-300 were selected and average of the counts was determined. The total plate count per g or ml of the sample was calculated using formula given below:

Cfu/g or ml=no. of colonies x dilution factor) / volume inoculated

Yeast and Mold Count
The yeast and mould counts in tomato powder samples were determined according to APHA, (1984) procedure by using potato dextrose agar (PDA) acidified with tartaric acid to pH 3.5+0.1 before pouring. Ten to fifteen ml of medium was poured in petri plates containing 1 ml of sample dilution, mixed well, solidified and incubated for 18-24 h at 37 °C in a Gallenkamp incubator (Model 1H-150, UK). The total yeast load after incubation was expressed as cfu/g after counting the colonies using the colony counter.

Results and Discussion
Physical quality characteristics
Physical quality characteristics of dehydrated tomato powder prepared at different temperatures are presented in Table.1. It is evident from the table that the tomato powder prepared at 50 °C and 60 °C were almost similar in color as revealed by hue and value however, tomato powder prepared at 70 °C was significantly darker in color which may be due to Maillard reaction that produces dark pigments as reported by (Anese *et al.*, 1999; Nguyen and Schwartz, 1999) [1, 19]. that heating of tomato, causes formation of dark colored Maillard reaction products (MRPs).The results for particle size distribution of tomato powder revealed that fineness of the powder increased with temperature increase. Finer particles were obtained by drying at 70 °C than 50 °C and 60 °C. Water absorption capacity was 280, 393 and 280 for tomato powder prepared

at 50 °C, 60 °C and 70 °C, respectively. The water absorption capacity increased with increase in fineness of flour in case of grains. However, in this case the water absorption capacity has decreased in the powder which has been prepared at 70 °C could be explained on the basis of moisture, carbohydrates, its derivatives and other organic acids which have been reported to have the largest effect in influencing the physical quality characteristics of the dried fruit powders.

Table 1: Physical Characteristics of Tomato Powder Prepared at Different Temperature

Drying Temp.	Physical Characteristics						
	Colour	Particle Size Distribution					Water Absorption Capacity
		36 mesh	60 mesh	85 mesh	100 mesh	After 100	
50 °C	2.5 YR (4/6)	70.9 + 0.48	29.86 + 1.86	0.66 + 0.20	N.D.	N.D.	280 + 0.5
60°C	2.5 YR (4/8)	15.68 + 0.60	31.71 + 0.86	31.37 + 1.27	12.85 + 0.25	2.94 + 0.14	393 + 0.5
70 °C	5 YR (5/4)	4.44 + 0.41	14.50 + 0.49	58.20+ 0.49	15.29 + 0.45	1.69 + 0.13	280 + 1.1

Antioxidant Activity

Antioxidant activity of the tomato powder prepared at different temperatures viz. 50 °C, 60 °C and 70 °C tested using the DPPH radical. The antioxidant activity of all the three variations of tomato powder has been illustrated in Fig.2. Absorbance of DPPH radical decreased as a result of color change as the radical is scavenged by antioxidants through donation of hydrogen to form stable DPPH-H. Theoretically, the more rapidly the absorbance decreases the more potent the antioxidant activity of the compound in terms of hydrogen donating ability. The DPPH free radical scavenging activities of various types of tomato powders were found between 45.41 to 58.00 per cent.

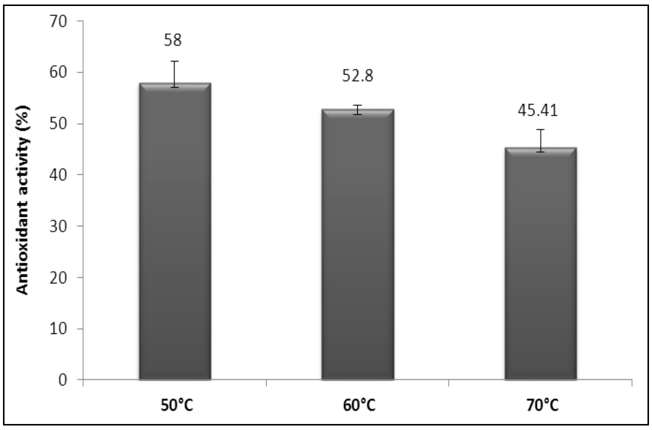

Fig 2: Antioxidant Activity of tomato powder prepared at different temperatures

The highest Antioxidant activity percent was found in tomato powder prepared at 50 °C while it was lowest in tomato powder prepared at 70 °C. The results indicated that the antioxidant activity decreased with increase of drying temperature. Martinez-Valverde *et al*., (2002) [16] also reported that antioxidant properties of tomatoes depend largely on lycopene content. The reason for the increased antioxidant activity of tomato powder prepared at 50 °C may be attributed to the increase in bioavailability of lycopene. It has been suggested that food processing improves bioavailability of lycopene by breaking down cell walls (Gartner *et al*., 1997) [9]. Homogenization and heat treatment disrupt cell membranes and protein-carotenoid complex, making carotenoid more accessible for extraction. Although, the bioavailability increases by processing treatments, heating time and temperature also play a role in stabilization of lycopene. Lycopene degradation follows a first order reaction (Demiray *et al*., 2013) [6].

It has been reported by various authors that lycopene content decreases as the temperature increases and heating time also has their own effect. Less than 10% loss of lycopene has been reported during the production of semidried tomato at 48 °C (Toor and Savage, 2006; Kong *et al*., 2010; Cinar, 2004) [25, 13, 5]. Seybold *et al*., (2004) [22] studied the effect of sterilization at 121°C for 2 minutes and pasteurization at 80 °C for 20 minutes in tomato juice. Results revealed 35 and 50% decrease of lycopene, during the sterilization and pasteurization, respectively. Mayeaux *et al*., (2006) [17] studied the stability of pure lycopene standard during heating from 100-150°C using HPLC and the results suggested a decreasing stability as the temperature increased from 100-150°C and time increased from 0-60 minutes which indicates that lycopene is susceptible to increase in heating temperatures. According to the study of Goula and Adamopoulos, (2005) [11] lycopene loss was between 8.07 - 20.93 percent during spray drying of tomato pulp and the loss increased as the air inlet temperature increased. As the lycopene content decreases in tomato powder, antioxidant activity also decreases because lycopene is majorly responsible for antioxidant potential especially of fat soluble fraction. However the thermal processing increases the amount of available lycopene, application of heat always decreases the amount of total lycopene present in food (Srivastava and Srivastava, 2015) [24] and thus resulting a decrease in antioxidant activity.

Microbial quality determination

Most of preserved foods deteriorate rapidly and become unacceptable to consumers in a limited time after production. The deleterious changes are primarily due to objectionable off-flavor induced by microbial activities. Short shelf life of foods deters their commercial production and distribution. To estimate the microbial load, TPC and yeast load were determined.

Total Plate Count

Total viable count of tomato Powder prepared at different temperatures viz. 50 °C, 60 °C and 70 °C was evaluated and the results are presented in Table 2. The total plate count of tomato powder dehydrated at 50 °C and 60 °C were approximately similar i.e. 36 x 10^4 cfu/g and 35 x 10^4cfu/g, respectively which showed that there was not much reduction in the microbial flora on an increase of temperature from 50 °C to 60 °C. However, there was a decrease in the total plate count on increase in temperature from 60 °C to 70 °C. For tomato powder prepared at 70 °C it was found lowest i.e. 14 x 10^4 cfu/g. The overall concentration of Total Viable counts were found lower in all types of tomato powder when compared to PHLS standards

(Gilbert *et al.*, 2000) [10] for dried vegetables which showed good microbiological quality of product in the experimental processing conditions used. The reference values as per PHLS guidelines are <10^5 (ACC; satisfactory) <10^5 -10^6 (ACC; acceptable) for dried vegetables. The samples at the stated temperature range and RH are expected to yield a better quality product possessing minimum chemical losses.

Table 2: Total viable count (TV) and yeast and mould count in tomato powder prepared at different temperatures

Temperature of Drying	Total Viable Count (Cfu/g)	Yeast and Mould count(Cfu/g)
50 °C	36 x 10^4	<0.5 x 10^2
60 °C	35 x 10^4	<0.5 x 10^2
70 °C	14 x 10^4	<0.5 x 10^2

Yeast and Mould Count

No yeast and mould growth was seen in all the samples of tomato powder so it was reported as nil or <0.5 x 10^2cfu/g.

Three time temperature combinations were tried for preparation of tomato powder. The results demonstrated that physical characteristics of powder differ for each combination. Antioxidant activity also decreases with increase in temperature of drying. TPC was found lowest i.e. 14 x 10^4 cfu/g, for tomato powder prepared at 70 °C. The overall concentration of Total Viable count were found lower in all types of tomato powder when compared to PHLS standards which showed good microbiological quality of powders prepared in the experimental processing conditions used. Keeping in view the processing parameters, resultant physical characteristics, antioxidant activity and microbiological criteria the tomato powder prepared at 60 °C for 12 h at 53% Rh was found superior and of optimum quality than the other two variations.

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